Perceptual and Motor Skills, 1991, 72, 772-774. © Perceptual and Motor Skills 1991

IMPROVED ARITHMETIC SKILLS OF FRENCH-IMMERSION GRADE-SCHOOL STUDENTS ARE CONFOUNDED BY HIGHER INTELLIGENCE [1]

P. FALTER
Sudbury Board of Education

M. A. PERSINGER
Laurentian University

Summary.—A total of 372 Grade 4 and 275 Grade 7 students were given a mathematics and a group-administered IQ test. About half the number of students in each grade were enrolled in either the regular (English) or the French Immersion program. There were no differences on mathematics scores or IQs between students from the two language programs in Grade 4. However, Grade 7 French Immersion students displayed significantly higher mathematics scores and IQs relative to regular classroom students; the program effect explained no more than 7% of the variance. When IQ was controlled, the differences in mathematics scores were not significant.

Continuous exposure to a second language within the school setting that is different from the home environment might be expected to compromise conceptual development. The argument assumes the existence of a finite limit in the capacity for consolidation during early childhood. Assuming that the early acquisition of both arithmetic operations because spatial-dependence is stronger (Reitan, 1984) and a second language involves more right hemispheric involvement than for similar processes in the adult brain, competition might be expected because of the principle of "crowding" (Kolb & Whishaw, 1990).

Previous studies (Genesee, Tucker, & Lambert, 1976; Barik & Swain, 1978; Fu & Edwards, 1984) have assessed children during the initial acquisition phase, i.e., Kindergarten through Grade 5. However, basic language skills asymptote around Grade 7 during which time auditory sequencing and visual "gestalt" recognition rather than visual decoding prevail (Gaddes, 1985). We decided to test whether or not total exposure to a second language would adversely affect the acquisition of mathematical concepts over a longer period of formal grade-school education.

A total of 647 boys and girls in Grade 4 and Grade 7 from 19 different schools served as subjects. There were 10 regular Grade 4 classes (n = 155), 10 French Immersion Grade 4 classes (n = 217), 6 regular Grade 7 classes (n = 144), and 6 French Immersion Grade 7 classes (n = 131) involved in the study. Children within the French Immersion program had started in Grade 1; the program required instruction and interaction in French during the school day; however, English was the primary (home setting) language for all of these students.

Each child was given the Otis-Lennon intelligence test and a mathematics examination. The mathematics examination was composed of 23 items for Grade 4 students and 28 items for Grade 7 students; the proportion of content (e.g., geometry, problem solving) was based upon guidelines set by the Ministry of Education and was grade-appropriate (consequently different items were used for each grade). Each test required about 40 min.; both were administered and scored by the first author during February, 1989. Two-way analyses of variance were performed between programs (regular vs French Immersion) and grades (4 vs 7) for both the mathematics examination scores (despite differences in items, to discern any statistically significant grade by

[1]Please send reprint requests to Dr. M. A. Persinger, Neuroscience Laboratory, Laurentian University, Sudbury, Ontario, Canada P3E 2C6. Pat Falter is Superintendent, Sudbury Board of Education, Civic Square, West Tower, 200 Brady St., Sudbury, Ontario P3E 5K3.

language interactions) and the IQ measure. Analyses of variance after covariance controlling for IQ were completed for the mathematics scores. Pearson correlations between the two scores were completed for each grade. All analyses were completed by SPSS^X software on a VAX 4000 computer.

Analysis of variance indicated that children within the French Immersion program scored higher ($F_{1,643} = 8.72$, $p < .01$; *eta* = .13) than children in the regular program while children in Grade 7 scored higher than those in Grade 4 ($F_{1,643} = 7.67$, $p < .01$; *eta* = .12); the statistically significant interaction ($F_{1,643} = 5.86$) was due to the greater decrease in mathematics scores between Grades 4 and 7 in the regular program compared to the absence of significant decrease in the French Immersion classes. The significant language difference ($F = 7,67$, $p < .01$) and interaction of language by grade ($F = 4.24$, $p = .03$) were still present when *T*-scores of mathematics accuracy for each grade were calculated separately and compared. Similarly, the children in the French Immersion program displayed higher IQs ($F = 17.79$, $p < .001$; *eta* = .14) than students in the regular program, and children in Grade 7 displayed higher scores than those in Grade 4 ($F = 24.53$, $p < .001$; *eta* = .17). The interaction was not statistically significant.

The means and standard deviations (in parentheses) for the mathematics scores and IQs for each of the program-classes were: Regular scores Grade 4: 12.9 (4.9) and 104.2 (12.47); Regular scores Grade 7: 10.9 (5.2) and 105.7 (12.3); French Immersion Grade 4: 13.2 (3.9) and 105.3 (12.1), and French Immersion Grade 7: 13.2 (4.0) and 111.8 (11.1). Pearson correlation coefficients between the mathematics scores and IQs for these groups were 0.66, 0.59, 0.65, and 0.65, respectively. Initial covariance for IQ before the analysis of variance eliminated the program effect ($F_{1,642} = 0.15$, $p > .05$) and the interaction of program by grade ($F = 2.72$) but did not alter the grade differences ($F = 54.31$, $p < .001$); the IQ covariate was significant ($F = 385.23$, $p < .001$; $r = .60$).

To minimize the error variance associated with combining grades (because different, although age-appropriate items were included in the mathematics tests), separate one-way analyses were completed for each grade. While the difference in mathematics ($F_{1,370} = 0.46$, $p > .05$) and IQ ($F = 3.89$, $p > .05$) were not statistically significant at Grade 4, they were statistically significant ($F_{1,273} = 11.60$, $p = .001$ and $F = 17.96$, $p < .001$) at Grade 7; the type of program explained 4% and 6% of the variance for the mathematics scores and IQs, respectively. However, when IQ was held constant (covariate $F = 195.05$, $p < .001$), the mathematics effect was no longer statistically significant ($F = 0.87$).

Chi-squared analyses (5.21, $p = .02$) indicated that the proportion of students in the French Immersion program decreased between Grades 4 and 7 compared to the increase in the regular program; 47% of the regular program students were in Grade 7 while 39% of the French Immersion students were in Grade 7. Assuming a quasiconstant system, one would expect that the 31 (less bright) students who constituted the exact discrepancy would have returned to the regular program. Whereas the addition of a random selection of 31 regular program Grade 7 students whose IQs were less than 105.7 to the French Immersion Grade 7 group did not eliminate the significant program differences, addition of 31 regular program students whose IQs were less than -0.5 *SD* of the mean to the French Immersion program group totally eliminated the statistically significant discrepancy for both mathematics scores and IQs.

We conclude that exposure to a second language of instruction during grade school does not interfere with the acquisition of mathematical concepts. Although children who remain within the French Immersion program are psychometrically brighter (at least within the limits of a group-administered paper-and-pencil inference of intelligence), their mathematical performance is not adversely affected. The fact that only 7% of the variance in IQ was explained by program of instruction indicates that this measure of scholastic brightness has a minimum effect upon the learning of mathematical concepts.

The reader might wish to remember that the measurements employed in this study would not have reflected: (1) initial (Grades 1 through 3) difficulties in the general acquisition of lan-

guage or arithmetic skills and (2) pupils who exited the program because these difficulties occurred before Grade 4. The incidence of psychological and neuropsychological referrals for Grade 1 through Grade 3 children in the French Immersion program suggests that the latter possibility deserves further scrutiny, especially for boys. We did not examine the potential differences between boys and girls in the present study.

REFERENCES

BARIK, H. C., & SWAIN, M. Evaluation of a French immersion program: the Ottawa study through Grade 5. *Canadian Journal of Behavioural Science*, 1978, 10, 192-201.

FU, L., & EDWARDS, H. P. Mathematics achievement: effects of language instruction and teacher's use of new curriculum materials. *Canadian Journal of Behavioural Science*, 1984, 16, 120-129.

GADDES, W. H. *Learning disabilities and brain function*. New York: Springer-Verlag, 1985.

GENESEE, T., TUCKER, G. R., & LAMBERT, W. E. Communication skills of bilingual children. *Child Development*, 1976, 46, 1110-1114.

KOLB, B., & WHISHAW, I. Q. *Fundamentals of human neuropsychology*. New York: Freeman, 1990.

REITAN, R. M. *Aphasia and sensory-perceptual deficits in children*. Tucson, AZ: Neuropsychology Press, 1984.

Accepted April 10, 1991.